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ABSTRACT

The technical reports summarized in this paper were prepared as part of a project designed to determine what is known about the teaching of cognitive skills and to formulate questions relating to such teaching for further research. Topics discussed in the 22 reports include the following: (1) teaching thinking; (2) Aristotle's logic; (3) a conceptual framework for the teaching of thinking skills; (4) a theory of plausible reasoning; (5) structure mapping; (6) counting, computing, and the representation of numbers; (7) computer programing as a vehicle for teaching thinking; (8) problem theory; (9) the teaching of informal reasoning; (10) the nature of intelligence; (11) microcomputers in education; (12) understanding understanding; (13) the teaching of learning strategies; (14) retrieval inhibition for part-list cuing; (15) teaching study strategies; (16) inquiry dialogue on the nature of lenses; (17) analogical development and the novice expert shift; (18) memory search of semantic categories following exposure to category instances; and (19) approaches to training information processing and problem solving skills. (FL)

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Report No. 5560

RESEARCH ON THE TRAINING OF HIGHER COGNITIVE LEARNING AND THINKING SKILLS

January 1984

Final Report

Contract 400-80-0031

Prepared by:

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1. INTRODUCTION

This is the Final Report for contract 400-80-0031. The project began in October 1980 and has continued for three years and four months. The objectives of the project as set forth in BBN Proposal No. P80-ISD-102, and incorporated by reference in the contract, were as follows:

- To determine what is known about the teaching of cognitive skills, drawing information both from the research literature and from the results of efforts to develop cognitive enhancement programs.
- To organize this information in a form, or forms, that will be useful to researchers who may wish to do further work on this subject, and to educators who may wish to implement a cognitive enhancement program in their own context.
- To identify questions relating to the teaching of cognitive skills that require research.
- To initiate research on some of those questions.

The realization of these objectives is documented in a series of Quarterly Progress Reports and Technical Reports that have been submitted to NIE over the life of the project, or that are submitted herewith. This Final Report is organized in terms of the Technical Reports that have been prepared, which, for convenience, we have classified in five categories: report describing programs to teach thinking skills, theoretical reports, literature reviews and syntheses, reports of empirical research, and others. Some of these reports have been published and some have been accepted or invited for publication. The

status of each is indicted in parentheses following the title and name of the author(s). Some of the remaining reports will probably also be published eventually in one form or another.

2. REPORT DESCRIBING PROGRAMS TO TEACH THINKING SKILLS

- Teaching Thinking, R.S. Nickerson, D.N. Perkins, and E.E. Smith. (To be published as a book.)

This book deals with the problem of teaching thinking. It is organized in three parts. In Part I we discuss several concepts and conceptual distinctions by way of providing a background against which to view various approaches to the teaching of thinking skills. We begin this part with an informal consideration of the concept of intelligence, inasmuch as the concept relates rather directly to the concept of thinking, and one's understanding of what intelligence is may predispose one to one or another bias regarding the teachability of thinking skills. We consider a variety of perspectives on thinking and, in particular, the usefulness of the notion of "thinking skills." We discuss problem solving, creativity, and metacognition because there is an experimental literature around each of these topics that is highly relevant to our general subject. We end this part with a review of a variety of common reasoning deficiencies. The fact that the commonality of these deficiencies is easy to document helps make the case for the need of more effective methods for the teaching of thinking.

In Part II we review several attempts that have been made to develop thinking-skills programs. This review is not exhaustive--we are aware of many programs that are not described and there undoubtedly are many more of which we are unaware--

however we believe that the programs included are a representative sample of those that exist. Our review is more descriptive than critical, primarily because in most cases compelling evaluation data have not been obtained. We venture opinions regarding strengths and weaknesses of specific programs; however, we urge readers to seek out original sources for programs of special interest, so as to form their own opinions of their merits. Our hope is that this book will provide a broad context within which individual programs may be viewed and useful pointers to more complete information.

In Part III we discuss the issue of program evaluation and we consider the question of what the evidence, on the whole, indicates regarding the teaching of thinking skills. What do the results of the various efforts described in Part II suggest regarding the legitimacy of the teaching of thinking as an educational objective? What guidance do they provide to teachers and researchers who wish to teach thinking or to work on the development of new and more effective techniques for doing so? (From the Introduction)

3. THEORETICAL AND CONCEPTUAL REPORTS

- Aristotle's Logic, M.J. Adams, BBN Report No. 5275. (To be published in G. Bower (Ed.) Psychology of Learning and Motivation, Academic Press.)

This paper is about the old question of the relation between Aristotelian logic and thought. The approach, however, is backwards relative to the norm. Specifically, the documented data on thought is accepted and, with that as a base, the logic is scrutinized. The idea stemmed from the observation that authorities disagree as to how many of the syllogistic pairs of premises yield valid conclusions. Among the answers cited are 14, 18, 19, 24, and 27. The suggestion in this paper is that at least part of the common man's apparent irrationality may be owed instead to the logic.

A proof is given of how many of the syllogisms are indeed valid. The proof is transparent, and it clearly defines likely sources for a number of classes of reasoning errors. Moreover, it suggests a much simpler set of rules to which Aristotle's can be reduced. With this understanding of the logic in hand, the historical and experimentally documented sources of confusion are compared. They turn out to be very closely related. Moreover, such ostensibly different models of syllogistic reasoning as Guyote and Sternberg (1981) vs. Johnson-Laird and Steedman (1978) prove to be essentially isomorphic when one considers that they were based on different models of the logic. Finally, after sorting out the various historical confusions and playing down

the logic to its reduced form, the laws that are left correspond very closely with people's normal performance. (Abstract.)

- An Outline of a Conceptual Framework for the Teaching of Thinking Skills, B. Bruce and E.E. Smith, BBN Report No. 4844.

In this paper we first propose a taxonomy of the basic types of knowledge needed for good thinking. Next, we consider each taxonomic type in turn, considering its contents and its use. then, we note a few implications of our taxonomy for describing poor thinking and for specifying how to teach thinking skills. Finally, we use our taxonomy to characterize several existing programs for teaching thinking skills. (From the introduction)

- A theory of Plausible Reasoning, A. Collins and R. Michalski. (draft)

The paper describes a formal system based on Michalski's variable-valued notation that characterizes the different types of plausible logic inference humans make in reasoning about the world. The work is based on the plausible inferences that frequently occur in people's answers to questions In this sense it is a major departure from logic, which is based on normative theories of reasoning. Because the theory is descriptively based, it includes a variety of inference patterns that do not occur in logic-based theories. A central goal of the theory is to specify the parameters such as the degree of typicality or similarity that affect people's certainty in making different plausible inferences. (Abstract)

- Structure Mapping: A Theoretical Framework for Analogy, D. Gentner, BBN Report No. 5192. (Published in Journal of Cognitive Science, 1983, 7(2), 155-170.)

A theory of analogy must describe how the meaning of an analogy is derived from the meanings of its parts. In the structure-mapping theory, the interpretation rules are characterized as implicit rules for mapping knowledge about a base domain into a target domain. Two important features of the theory are (a) the rules depend only on syntactic properties of the knowledge representation, and not on the specific content of the domains; and (b) the theoretical framework allows analogies to be distinguished cleanly from literal similarity statements, applications of abstractions, and other kinds of comparisons.

Two mapping principles are described. (a) Relations between objects, rather than attributes of objects, are mapped from base to target; and (b) The particular relations mapped are determined by systematicity as defined by the existence of higher-order relations. (Abstract)

- Thoughts on Teaching Thinking, R.S.Nickerson. (Published in Educational Leadership, 1981, 30, 21-24.)

A program to enhance thinking might reasonably focus on four types of objectives: abilities, methods, knowledge, and attitudes. The term abilities is intended to connote specific things one might want students to be able to do. Methods refers to structured ways of approaching tasks and subsumes the notions

of strategies, procedures, and heuristics. Knowledge refers to facts, concepts, or principles that one might want students to understand. Attitudes refers to points of view, perspectives, or opinions that one might want students to adopt. This taxonomy, like most others, has some arbitrariness about it. It does, however, provide a convenient frame of reference for discussing some important aspects of improving intellectual performance. (From the introduction)

- Counting, Computing, and the Representation of Numbers, R.S. Nickerson, BBN Report No. 5172.

How easy it is to manipulate numbers depends in part on how they are represented visually. In this paper, several ancient systems for representing numbers are compared with the Arabic system, which is used throughout the world today. It is suggested that the superiority of the Arabic system as a vehicle for computing is due in large part to the compactness of its notation. The greater compactness has been bought at the cost of greater abstractness. Numbers in the Arabic system bear a less obvious relationship to the quantities they represent than do numbers in many earlier systems. Moreover, the elementary arithmetic operations of addition and subtraction are also more abstract; in some of the earlier systems the addition of two numbers is similar in an obvious way to the addition of two sets of objects, and the correspondence between subtraction with numbers and the subtraction of one set of objects from another is

also relatively direct. The greater abstractness of the Arabic system may make it somewhat more difficult to learn, and it may obscure the basis for such elementary arithmetic operations as carrying and borrowing. The power of the system lies in the fact that once it has been learned it is the most efficient of any system yet developed for representing and manipulating quantities of all magnitudes. (Abstract)

- Computer Programming as a Vehicle for Teaching Thinking Skills, R.S. Nickerson. (Published in Thinking, 1983, 4 42-48.)

Perhaps the basic reason for the belief that programming might be an effective vehicle for the acquisition of generally useful cognitive skills is the assumption that programming is prototypical of many cognitively demanding tasks. It is a creative endeavor requiring planning, precision in the use of language, the generation and testing of hypotheses, the ability to identify action sequences that will realize specified objectives, careful attention to detail, and a variety of other skills that seem to reflect what thinking is all about. Perhaps the best way to explore the plausibility of the assumption is to consider, in a conjectural way, what some of the generally useful cognitive skills that could be acquired through programming might be.

In what follows the term "skills" will be given a sufficiently broad connotation to include abilities, methods,

knowledge, and attitudes (Nickerson, 1981). The following conjectural list was produced with this connotation in mind. It contains examples of skills, broadly defined, that seem to be involved in programming and that one might therefore hope to be able to teach via the teaching of programming.

- Planning
- Anticipating
- Problem Decomposition
- Hypothesis Generation and Testing
- The concept of an algorithmic procedure
- The concept of a heuristic procedure
- The idea of a parameterized procedure
- The idea of a procedural hierarchy
- The importance of the precise use of language
- The importance of avoiding unnecessary complexity
- The fact that there are many ways to represent the same procedure
- The idea of indirect reference
- The difference between syntactic and conceptual errors
- The difference between functionality and elegance (Excerpted from article)

o Problem Theory, D.N. Perkins, BBN Report No. 5265.

The paper presents ten dimensions, nine binary and ne with four values, for characterizing problems of all sorts. The problems treated range from constructing proofs to such

open-ended tasks as writing a poem or advertising a product. The dimensions measure departure from "formality" as exhibited by problems like proving a mathematical theorem. The dimensions address factors such as whether the problem solver has access to full information about the current state of the problem (for example, yes for a proof, chess, or bowling, no for bridge), whether the state of the problem is only changed by the problem solver (yes for a proof, no for chess, bridge, bowling), whether the operations the problem allows can be reliably carried out (yes for a proof, no for chess, bridge, and bowling). The analysis considers the kinds of cognitive skills and style demanded by formal problems and various departures from formality and concludes by examining skills of formalizing and "de-formalizing" that cut across different problem types.

- o On the Teaching of Informal Reasoning, R.S. Nickerson, BBN Report No. 5577. (To be published in R.F. Dillon and R.J. Sternberg (Eds.) Psychology and Curriculum Design, Academic Press.)

This chapter draws one contrast between automatic and deliberate inferencing and another between closed and open-ended problems. It addresses the question of teaching informal reasoning of the type that involves deliberate inferencing on open-ended problems. The prototypical task of interest is that of figuring out what to believe in daily life and, more particularly, that of evaluating informal arguments. It is suggested that although the ability to evaluate informal

arguments rationally and reasonably is as important as most abilities we possess, we do not know how to improve this ability very much by training. Three types of impediments to effective reasoning in the evaluation of arguments are discussed: knowledge impediments, methodological impediments, and attitude impediments. It is suggested that efforts to teach informal reasoning should address all three types. (Abstract)

4. LITERATURE REVIEWS AND SYNTHESES

o What is Intelligence? M.J. Adams, BBN Report No. 4801.

Cross-cultural research has demonstrated time and again that, not just the level, but the pattern of people's performance on tasks designed to measure intelligence varies distinctively with their cultural and educational backgrounds. In this paper, several genres of verbal reasoning problems are examined in search of experiential factors that might work to support or distort their underlying logic. In each case, the factors turned up seem to operate on either the interpretation of the problem or the perception of its solution demands: that is, they appear to affect aspects of the solution that are orthogonal to the processes of logic or reasoning that the problems are intended to assess. The implications for cross-cultural assessment of reasoning are discussed. (Abstract)

o Microcomputers in Education, W. Feurzeig, P. Horwitz, and R.S. Nickerson, BBN Report No. 4798.

Computer-assisted instruction has been a topic of considerable interest among researchers and educators for more than 20 years. To date, accomplishments have not matched early expectations. One of the major limitations to progress in this field has been the high cost of computing resources. Recent advances in microelectronics technology and, in particular, the development of the computer on a chip, have greatly reduced the cost of computing hardware, and have also made possible the

packaging of very large amounts of computing power in portable devices. The trend of providing increasing amounts of computing power in increasingly smaller packages and at ever decreasing cost is expected to continue into the foreseeable future. This report is motivated by the belief that this trend has very substantial implications for the future use of computer technology in education. Following a cursory review of the history of computer assisted instruction, the capabilities of state-of-the-art microcomputers are described. Currently available microcomputer software with potential educational uses is then surveyed, and some anticipated future developments are discussed. (Abstract)

- Understanding Understanding, R.S. Nickerson, BBN Report No. 5087. (To be published in American Journal of Education.)

Several experimental studies are reviewed, the results of which suggest that students often fail to acquire an understanding of some of the concepts, relationships, principles, and processes that are fundamental to traditional high school course material. The question of what it means to understand something is considered. Several suggestions are made regarding how understanding might be facilitated in the classroom. (Abstract)

- Three Uses of Computers in Education, R.S. Nickerson, BBN Report No. 5178. (A portion of this paper was published under the title: Computer Programming as a Vehicle for Teaching Thinking Skills. See above.)

Computer technology has the potential to impact education in a variety of ways. This paper discusses three of them under the topics: (1) the computer as a general-purpose tool; (2) computer-assisted instruction; and (3) programming as a vehicle for acquiring generally useful cognitive skills.

Because the computer is a powerful general-purpose tool that is being used in more and more contexts, its use in schools and in educational activities is also increasing and undoubtedly will continue to do so. Increasingly easy accessibility of computing resources to students will encourage their greater use in educational activities and assignments, as will the growing significance that computer literacy is acquiring in the workplace.

Computer-assisted instruction, which to date has failed to fulfill early expectations, still shows enormous promise. The reasons for expecting CAI to be effective are compelling and the technology is rapidly approaching the point at which the use of computers to teach at least some aspects of conventional course material can be cost effective. The major impediment to more effective use of this technology at the present time appears to be the paucity of high-quality educational software. The software that has been developed for purposes of entertainment is superior in many respects to what is generally available for educational purposes. An especially attractive possibility is that of development of software that both educates and entertains.

The use of computer programming as a vehicle for the teaching of generally-useful thinking skills also appears to be a possibility that is sufficiently promising to warrant serious efforts toward that objective. Programming is prototypical of many cognitively-demanding tasks. Many of the abilities, methods, concepts, principles and attitudes that are likely to be acquired in the course of learning to program have broad applicability to other domains as well. It is not known to what extent skills that are acquired in the learning of programming spontaneously transfer to other contexts. Nor is it know how effective programming would be as a vehicle for teaching generally-useful thinking skills, if an explicit effort were made to use it for that purpose. It is suggested here that this approach to the teaching of thinking skills is worth trying, and several skills that might be candidate objectives for such an approach are identified. (Abstract)

- The Teaching of Learning Strategies, R.S. Nickerson, W. Salter, S. Shepard, and J. Herrnstein, BBN Report No. 5578.

Learning is being viewed more and more as an active process over which the learner can and should exercise considerable control. This view stands in sharp contrast to that which sees learners as passive receptacles standing ready to receive whatever information and knowledge teachers may choose to pour into them. It also raises the question of what is required to control and manage one's own learning. An interest in this

question has lead many researchers to attempt to identify effective "strategies" for learning, and to explore how they might be taught.

In this paper we review some of the work in this area and attempt to summarize what has been found to date. We begin with a discussion of the question of what a strategy is and contrast this concept with several related ones. We then consider some evidence that a variety of learning strategies are used spontaneously by students without being taught. We review the results of several effort to teach learning strategies under controlled conditions. On the basis of the results of these studies, we draw some conclusions about the teaching of such strategies. (Abstract)

- Retrieval Inhibition for Part-List Cuing: A Persisting Enigma in Memory Research, R.S. Nickerson, BBN Report No. 5574. (To be published in Memory and Cognition.)

When people are asked to recall words from a list they have just studied, or to produce as many items as possible from a well-known category (e.g., states of the United States), having available a subset of the items as recall cues often does not facilitate retrieval of the remaining items and sometimes inhibits it. The finding, which has been referred to as the "part-list cuing effect," has been obtained many times with a variety of experimental tasks, including recall from categorized and non-categorized lists and retrieval from very long-term

memory. This paper reviews the studies that have yielded the effect, and considers several explanations of it that have been proposed. None of these explanations is viewed to be entirely adequate and compelling. (Abstract)

5. REPORTS OF EMPIRICAL RESEARCH

- Teaching Study Strategies, A. Collins, D. Gentner, and A. Rubin, BBN Report No. 4794. (To be published in Cognition and Instruction.)

This paper describes an experiment in teaching study strategies to high school students. Its purpose was to investigate the transfer of some theoretical hypotheses about study skills into practice. A group of students was tutored on a one-to-one basis and their progress was monitored by a series of tests and observations of their studying and note-taking behavior. The results showed that tutored students scored progressively better on successive tests as compared to a matched control group of students. (Abstract)

- Inquiry Dialogue On the nature of Lenses, A. Collins. (To be published in C.N. Reigeluth (Ed.) Instructional Theories in Action: Lessons Illustrating Selected Theories and Models.)

We have studied a variety of inquiry teachers in order to abstract the goals and strategies they use in their teaching. Inquiry teachers have two overall goals. One is to teach a deep understanding of a particular domain so that students can make novel predictions about the domain. The other is to teach students to be good scientists, so that they can construct general rules and theories, and be able to test them out. The paper presents a dialogue constructed to illustrate aspects of inquiry teaching, together with an analysis of the specific strategies used by the teacher in the dialogue. (Abstract)

- Analogical Development and the Novice Expert Shift, D. Genter, BBN Report No. 5478.

There is a well-documented developmental improvement on tasks involving metaphor and analogy. This has generally been held to result from an age-related increase in cognitive capability. In this research we ask whether this improvement could result simply from an increase with age in knowledge about the specific domains of discourse (the knowledge hypothesis).

In two experiments, we compared interpretations of scientific versus general analogies by college science students with those of liberal arts students. If analogical development results from acquisition of domain-specific expertise, the science subjects should produce better interpretations of the science analogies than the liberal arts students.

The results provide no evidence for the domain knowledge hypothesis. The two groups of subjects showed no significant difference in their styles of analogic comprehension. The implications of these results for a knowledge-based view of analogical development are discussed. (Abstract)

- Are People's Estimates of What Other People Know Influenced By What They Themselves Know?, R.S. Nickerson, A. Baddeley, and B. Freeman, BBN Report No. 5573.

An exploratory experiment was done to investigate how our estimates of what other people know are influenced by what we

ourselves know. Two hypotheses were of interest: (1) that one is more likely to believe that other people have a particular bit of knowledge if one has it oneself than if one does not, and (2) that one is more likely to overestimate the commonality of knowledge that one has oneself than of knowledge that one does not have. Subjects answered questions selected from the set for which Nelson and Narens (1980) have provided norms. They also estimated the percentage of other people who would be likely to know the answers to these questions. The results were consistent with both hypotheses. (Abstract)

- Memory Search of Semantic Categories Following Exposure to Category Instances, R.S. Nickerson, E.E. Smith, and R.W. Wallach, BBN Report No. 4822.

Subjects generated as many words as they could from a specified semantic category (birds or countries) after having performed a list-learning task with words drawn from the same or a different category. Results were inconsistent with those of previous studies that had shown that increasing the availability of some of the items of a category, by presenting them in advance, impaired the subjects' ability to produce the remaining items in the category. In this experiment, degree of availability was manipulated by selecting for advance presentation items that typified the category to different degrees, and by giving the subjects different amounts of exposure to the items by means of a list-learning task. Increased typicality and increased exposure both increased the availability

of the items presented in advance (as evidenced by performance on the list-learning task), but neither decreased the availability of the remaining items in the category (as evidenced by performance on the subsequent list-generation task). An account of the discrepancy between these results and those of previous experiments is suggested, which invokes the notion of a two-stage search process that involves some random sampling with replacement. Other aspects of the results that are discussed include the fact that subjects generated more than twice as many names of countries as names of birds, although there are many more bird names than country names in the language, and the fact that subjects generated only a relatively small percentage of the possibilities in both cases. Plots of cumulative numbers of items produced versus time were fitted with exponential functions of the form $n(t)=n(\infty)\ (1-e^{\lambda t})$. The fact that $n(\infty)$, the asymptote of the curve, was inversely related to , the rate parameter, was taken as consistent with the idea that the number of non-target items in the search sets was small in comparison to the number of target items contained in them. (Abstract)

6. OTHER REPORTS

- Notes About Reasoning, R.S. Nickerson, BBN Report No. 5191. (Tc be published as a book.)

This is not a textbook on reasoning. No claim is made either for comprehensiveness or even for balanced coverage of the subject. Nor do these notes review the experimental literature on reasoning; indeed while allusions to experimental findings are sometimes made, the format that is typically used in preparing a review has been intentionally avoided.

The use of the term "Notes" in the title is a considered choice because that is what the document is--a set of notes. Thus the discursiveness of the style and sometimes fragmentary nature of the contents. And, as seems appropriate for a set of notes, this one contains a mixture of observations about reasoning that can be readily substantiated with data and expressions of opinion and conjectures that cannot. My main motivation for producing these notes was to help clarify my own thinking about the topics discussed, working on the assumption that the process of writing about a subject is as good a way as there is to force oneself to make one's ideas about that subject clear. There is also the possibility, of course, that the actual result is to make clear how fuzzy those ideas really are.

Nothing is assumed with respect to the reader except a general interest in the subject of reasoning and a tolerance for ideas that are still in the process of being formed. To the

extent that there is a target reader, it is a teacher at secondary school or junior college level. If any of these notes prove to be useful to someone who is trying to help students to become better reasoners, they will have more than served their purpose. It is, of course, a large step from ideas in the sketchy form of those presented here to fully developed curriculum material suitable for classroom use. On the other hand, one needs ideas from which to develop curriculum material, and it is hoped that some of those in these notes may be useful to that end. (From the Introduction)

- Methods, Fallacies and Games: Comments on Some Approaches to Training Information Processing and Problem Solving Skills, R.S. Nickerson, BBN Report No. 5576.

This paper is a commentary on three other papers presented at the 1983 American Educational Research Association Symposium on "The Trainability of Information Processes and Problem solving Skills," Montreal, Canada. The paper focuses on certain aspects of the papers that appear to the writer to be subject to debate.

7. OTHER ACTIVITIES OF NOTE

A mailing list of researchers and educators was prepared and forwarded to NIE. Names for the mailing list were obtained in a variety of ways, including through the following notice in ASCD Update, published by the Association for Supervision and Curriculum Development:

> Educators and researchers working with programs to enhance thinking skills are being studied by Bolt Beranek and Newman for the National Institute of Education. Educators and researchers working with such programs may be on the mailing list by sending their name, address, position, whether researcher or practitioner, and nature of their activity or interest to Brenda Starr; Bolt Beranek and Newman Inc.; 50 Moulton Street; Cambridge, MA 02238.

Most of the people who responded identified themselves as practitioners.

Several cognitive-skills training programs were visited during the course of the project. Among them were Michael Cole's program at the University of California at San Diego, which is centered on the Teaching of metacognitive and problem-solving strategies, the Instrumental Enrichment program of Reuven Feuerstein as implemented in Nashville Tennessee, the Philosophy for Children program of Matthew Lipman as implemented in

Secaucus, Totowa, and Union City, New Jersey, and the Thistle program in Newark, New Jersey.

A symposium on "Purposes for Teaching Purpose" was organized for the Annual Meeting of the American Educational Research Association on March 21, 1982. The objective of the symposium was to discuss a variety of ways in which the teaching of purpose can facilitate the attainment of other educational goals. The three formal presentations focused on: (1) the importance of an understanding of purpose to the development of reading and writing skills, (2) relative effectiveness of a purpose-oriented approach to teaching procedural knowledge, and (3) the teaching of purpose as a way of improving study skills. The symposium was organized by R.S. Nickerson, the three presenters were B.C. Bruce, A. Rubin, (Purpose in Reading and Writing); E.E. Smith, (Purpose in the Giving and Following of Instructions); A. Collins, D. Gentner, A. Rubin, (Purpose in Teaching Skills). The discussant was Bonnie Armbruster of the University of Illinois. Synopses of the three formal presentations can be found in Quarterly Progress Report No. 6.

At the request of NIE, we participated in an Expert's Meeting on "The Impact of New Information Technologies on Learning Processes and Equality of Opportunities" at the Center for Educational Research and Innovation in Paris on December 16, 17, 1982. Notes from the meeting were forwarded to NIE.

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